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CHRONIC ARTHRITIS IN SWINE

PLATES 10 AND 11

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Arthritis is a comparatively frequent lesion in domestic animals and occurs in association with other pathologic conditions which correspond quite closely with those in man. Thus, arthritis is met with in acute general infections, such as postpartum infections in cattle, and following umbilical infections in calves and foals, and in epidemic streptococcal infections in horses and cattle; in chronic local infections of the mammary gland in cattle and swine, chronic forms of arthritis are found; in other animals including swine, cattle and other domestic animals, chronic arthritis of one or more joints is seen without other clinically evident infections.

Chronic arthritis with varying degrees of enlargement and deformity of joints is met with in otherwise apparently healthy market hogs. Such chronic lesions usually involve one or two joints, and occur sporadically, or there may be several instances in one herd. The lesions may correspond quite closely with certain forms of chronic deforming arthritis in man, in which symptoms of general infection, and for considerable periods also, marked nutritional disturbances may be absent.

The present study includes an examination of joints from 21 cases of arthritis in market hogs, the degree of joint involvement of which varied from a slight enlargement of the joint to extensive disorganization and deformity, in some instances suggesting in external appearance chronic tuberculosis. We have ascertained the pathogenic properties of such organisms as were isolated, by experiments in animals of the same species, thereby avoiding the factor of abrupt change of the host of the invading organism. The importance of the species of the experimental host, in modifying lesions produced by bacteria, seems not always to have received the attention it deserves.

Of the organisms which have been found in infections with arthritis in domestic animals Bacillus pyogenes has received most attention. Glage[1] has collected the literature concerning acute and chronic

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[1] Kolle u. Wassermann, Handbuch d. path. Mikroorganismen, 1913, 6, p. 148.

infections of domestic animals. Ward[2] has well summarized the lesions produced by B. pyogenes in swine and cattle, and noted a case of arthritis with periarticular abscesses caused by this organism.

The opportunity to examine hogs suffering from chronic arthritis, to secure the joints for study, and to obtain young swine for experimental study of arthritis, we owe to Mr. A. G. Leonard of the Union Stock Yards, Chicago. We thank also Dr. S. E. Bennett, veterinarian of the Union Stock Yards, and the veterinarians of the U. S. Department of Agriculture stationed at the stock yards, and officials of Swift & Company for cooperation in obtaining material.

The joints for examination were obtained fresh from hogs on the killing floor of Swift & Company and transported to the laboratory for examination. This material presented several advantages for study. The joints came as a rule from otherwise healthy hogs, of which complete veterinary inspection was made for visceral lesions, and whatever pathologic changes were found noted. The joints were thus examined at a time in the course of the arthritis when they were still serviceable, and complete dissections, sections and cultures from fresh material were possible. It is evident, of course, that this material is a selected one in respect to the subject of arthritis in swine, since it came from a group of animals in which whatever disease was present had not materially interfered with the growth, fattening, and suitability of the hog for market.

REPORT OF CASES

1.—The right hock joint was spindle-shaped and swollen; the overlying skin was not changed. The capsular tissue was found everywhere much thickened, tough, fibrous, in places calcified, the surface cartilage of the head and socket was denuded in corresponding places and covered with granulation tissue. The synovial membrane was replaced by villous granulation tissue. markedly in the upper recesses. The posterior ligament was hard and calcified. The cavity of the joint contained a small amount of odorless, slightly turbid exudate. The tonsils of both sides were enlarged and showed several whitish-yellow spots 1-2 mm. in diameter. Microscopically the granulation tissue in the synovial villi showed plasma and round cells and new capillaries. In the part where the cartilage was denuded, the granulation tissue encroached on the bone marrow and contained numerous giant cells; proliferation of cartilage cells and new formation of bone were noticed at the edges. Gram-positive diplococci were found in the granulation tissue and bone marrow.

The sections of the tonsils showed several small cavities with granular contents, staining homogeneously violet with hematoxylin, surrounding which was dense connective tissue without any giant cells or epithelioid cells. Gram-positive diplococci and plump bacilli were present in the abscesses. The smears of the joint exudate and the granulation tissue contained gram-positive diplococci and fewer gram-positive and gram-negative, short bacilli. Cultures of dilutions of the exudate gave Staphylococcus albus, a hemolytic streptococcus, and gram-positive short bacilli. Inoculations from the tonsils on blood agar gave principally hemolytic streptococci.

2.—The right carpal joint was swollen; no sinus; a small amount of clear exudate; the cartilage was almost intact, except for a round area of ulceration of the socket of os naviculare; reddish, hyperemic granulation tissue beneath the capsule and in interosseal spaces; posterior ligament calcified.

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[2] Cornell Veterinarian, 1917, 7, p. 29.

In the tough, scarlike connective tissue of the joint capsule were tags of granulation tissue with mucoid degeneration in some places; plasma cell infiltration marked. The edge of the denuded cartilage was rather sharply defined with no sign of bone regeneration. Gram-positive cocci in section of granulation tissue. The tonsils were small, no abscesses.

The smears from the joint exudate showed gram-positive diplococci and short bacilli. In fluid cultures, streptococci of short chain (8-12) and gram-positive short bacilli developed. On blood agar cultures from the exudate and subcultures from fluid mediums developed colonies of hemolytic streptococci but no bacilli. Carbolfuchsin stains of smears and sections for tubercle bacilli gave negative results.

3.—Hock joint enormously swollen; two sinuses anteriorly, one with undermined edges. The sinuses led into a cavity filled with greenish-yellow pus, in places very thick. The marrow of os cuneiforme was exposed inside this cavity, and the surface cartilage of the os cuboideum was replaced by edematous fibrous tissue. In the periarticular fibrous tissue were two areas of granulation tissue, with caseous spots in the center. The entire appearance resembled joint tuberculosis. The tonsils were enlarged with several rice-sized yellowish spots on the surface.

Microscopically the granulation tissue from bone and capsule showed new capillaries and infiltration chiefly with neutrophil polymorphous cells, in places round and plasma cells. Neither epithelioid nor giant cells were found. In sections of bone the granulation tissue was seen to have destroyed the cartilage and to have entered the marrow spaces; small islands of cartilage were surrounded by the granulation tissue; in the epiphyseal part the fatty marrow was replaced by cell infiltration. Gram-positive diplococci were found in numbers in the granulation tissue, especially in the edges toward the cavity.

The tonsils contained irregularly shaped small abscesses surrounded by hyaline fibrous tissue; neither giant cells nor epithelioid cells were found; the abscess contents showed relatively small number of gram-positive cocci; no tubercle bacilli.

Smears of the joint exudate contained a number of gram-positive diplococci; no tubercle bacili (antiformin). Cultures gave minute hemolytic colonies of streptococci exclusively. Cultures of the tonsils gave hemolytic streptococci, large whitish colonies of gram-negative bacilli (colon) and one small reddish colony of yeast.

4.—Hock joint swollen and ankylosed; capsule thick; small amount of clear viscid fluid in joint cavity; hyperemic granulation tissue beneath the capsule in front; cartilage of the cuboid bone denuded in one small spot; other bones normal; tonsils normal.

Microscopically the villous proliferation in the synovia contained many capillary vessels and plasma cells; also a few gram-staining bacilli. Cultures sterile.

5.—Carpal joint swollen; beneath capsule a layer of granulation tissue, internal ligament torn away in opening joint taking with it bone which seemed to be undermined by granulation tissue. Articular surface fairly smooth, except in depths of depressions.

Gram-positive, short bacilli were scattered about in the granulation tissue; smears of joint fluid showed a few coccal and bacillary gram-positive organisms. On blood agar, minute, semitranslucent nonhemolytic colonies of gram-positive, short bacilli were obtained.

6.—Some enlargement of hock joint, due to capsular thickening; no disorganization; clear exudate; small amount of granulation tissue inside joint, and microscopically proliferation of synovial tags which in some places were replaced by granulation tissue with much plasma cell infiltration; the superficial layer of cartilage involved in fibrillation and deeper layers showed cartilage cell proliferation; many giant cells in marrow spaces. Gram-positive, short bacilli in granulation tissue, and smears of exudate also showed a few such bacilli. The cultures gave minute, nonhemolytic colonies of gram-positive bacilli.

7.—Moderate sized elbow joint with some periarticular thickening, otherwise no deformity; but little change in the cartilage; small amount of granulations around internal ligament. In sections a few gram-positive short bacilli in granulation tissue; smears and cultures, however, gave no organisms.

8.—Hock joint, about the same as in Hog 7; smears and cultures showed no bacteria.

9.—Large stifle joint; some thickening of capsule and erosion of cartilage at more prominent points in joint, so that the bone was exposed; posterior part showed more granulation tissue than in front; microscopically the remnants of surface cartilage were surrounded by granulating fibrous tissue and at the edges of the ulcers was new formation of bony tissue; plasma cells in granulation tissue and many giant cells in bone marrow; gram-positive, short bacilli with some coccal forms in the tissue and smears, and on blood agar cultures nonhemolytic, minute, semitranslucent colonies of gram-positive bacilli.

10.—Six months old hog; right hock joint enormously swollen; two sinuses in skin over front of joint leading to bursae containing thick putty-like, greenish-gray or yellowish-gray pus; larger portion of enlargement due to areas of capsular thickening, in center of which are collections of thick pus; some of the bursae intact, not opening internally or into joint, except one which opened into joint; cartilage intact, no eburnation; areas of more recent inflammation with synovial exudate. Microscopically, the surface cartilage of several bones was denuded and replaced by granulating fibrous tissue with round cells and plasma cells; many giant cells in marrow, not of Langhans' type; no caseous degeneration; regionary lymph glands show inflammatory reaction. Stains for tubercle bacilli negative. By Gram method bacteria of coccal form were demonstrated in the granulation tissue.

Guinea-pigs injected intraperitoneally with joint exudate after treatment with antiformin did not develop tuberculosis.

Smears of joint fluid and of lymph-nodes revealed the presence of gram-positive cocci and bacilli. On blood agar minute, slightly hemolytic colonies of gram-positive, short bacilli and stronger hemolytic colonies of gram-positive cocci were obtained. The latter developed short chains in fluid mediums.

11.—Carpal joint swollen, especially anteriorly; medium amount of cloudy serous exudate in cavity; granulation tissue filled up the interosseal spaces; surface of cartilage denuded at several points; in joint cavity two small pea-sized necrotic masses.

Nasal polypus on both sides but no sign of inflammation or exulceration; accessory sinuses normal.

Microscopically the necrotic masses were found to be pieces of degenerated bone tissue.

Gram-positive short bacilli were stained in sections and smears. Blood agar cultures gave nonhemolytic, minute colonies of gram-positive short bacilli.

12.—Slight swelling of carpal joint; capsular tissue slightly thickened, fibrous, moderate amount of slightly cloudy, yellowish, viscid fluid in joint cavity; synovial tags proliferated in anterior part, and markedly hyperemic. Cartilage intact. The changes were those of a mild proliferative type of synovitis. There was some bloody muco-pus in the left upper nasal meatus and left maxillary sinus. Ethmoid and frontal sinuses larger than usual, but otherwise normal. Microscopically was found proliferation of synovial tags and granulation tissue in places beneath capsule. Sections and smears did not show any organisms. On blood agar cultures from the joint, however, minute nonhemolytic colonies of gram-positive bacilli developed.

13.—Right hock joint enormously enlarged with one large sinus in front. A large abscess in lateral periarticular tissue containing greenish-yellow pus, connected with joint cavity by two fistulae; capsular tissue thick, fibrous, in places edematous; the joint cavity filled with thick pus and granulating fibrous tissue; surface cartilage of several bones denuded; bone marrow replaced by granulation tissue; in some parts by caseous material. Microscopically there was found much destruction of cartilage and bone tissue; fatty marrow almost replaced by granulation tissue with numerous giant cells; many gram-positive diplococci were found in granulation tissue and smears of joint exudate; on blood agar small colonies of hemolytic streptococci in short chains developed.

14.—Hock joint swollen; capsule fairly thick; no marked exudate in cavity; granulation tissue lined the capsule; surface cartilage of some bones tough and fibrillated; gram-positive bacilli in tissue, smears and cultures.

15.—Stifle joint swollen; hock joint normal; capsule fairly thick; in cavity some slightly cloudy serous exudate; cartilage and bone not destroyed; no organisms in smears or cultures.

16.—Hock joint swollen; granulation tissue beneath the capsule, especially in front, filling up interosseal spaces; small amount of thick pus in cavity; cartilage denuded over opposing articulating surfaces; a small abscess with inspissated pus in bone. Microscopically there was found besides the destruction of cartilage and bone-tissues, new formation of bone with layers of osteoblasts. Smears and cultures gave gram-positive bacilli.

17.—Carpal joint swollen; capsule thick and fibrous; some clear viscid exudate; proliferation of synovial tags, more in front; no destruction of cartilage or bone. Sections, smears and cultures failed to reveal any bacteria.

18.—Hock joints of both sides swollen, anchylosed; conditions similar on both sides; bony union of tarsal bones with obliteration of interosseal spaces; between tibia and tarsum small amount of viscid fluid; granulation tissue within the capsule.

Accessory nasal sinuses free from inflammation; tonsils normal. Sections of granulation tissue and smears contained gram-positive bacilli. On blood agar minute nonhemolytic colonies of the same bacilli developed.

19.—Conditions about the same as 18. In sections, smears and cultures gram-positive short bacilli were obtained. On blood agar faintly hemolytic colonies of bacilli appeared.

20.—Carpal joints of both sides showed reddish vascular granulations, more marked about the periphery; cartilage intact; smears and sections contained short bacilli, gram-positive; blood agar plates gave minute nonhemolytic colonies.

21.—Hock joints of both sides swollen. On opening right joint thick greenish-white necrotic material was found outside it but communicating with cavity; much granulation tissue about joint; at one point the bone was softened and fragments of bone lay in the necrotic material. This joint suggested in appearance tuberculosis.

Similar changes in the left joint; the bone was but little involved, large periarticular abscess along tendon sheath. Marrow spaces filled with granulation and fibrous tissue. Smears and sections of granulation tissue revealed gram-positive short bacilli and diplococci. On blood agar appeared hemolytic colonies of streptococci and nonhemolytic colonies of short bacilli. No evidence of tuberculosis. The tonsils were 1.5 x 3 cm. and contained many small yellowish, calcified nodules, ½ x 2 mm. in diameter. On culture of tonsils colonies of a hemolytic streptococcus developed.

Carbolfuchsin stains of sections and smears, serum cultures after antiformin treatment and intraperitoneal injection of guinea-pigs all failed to demonstrate tubercle bacilli.

SUMMARY OF OBSERVATIONS ON THE SPONTANEOUS DISEASE

Of 21 cases examined hemolytic streptococci were found in 2, bacilli in 9, to be discussed later, streptococci and bacilli in 4; 4 cases yielded no organisms in smears, sections and cultures, and in 2 bacteria were discovered in either smears or sections, but failed to grow in cultures.

Most of the 6 cases, which did not yield any organisms at all or not in cultures, showed comparatively slight pathologic changes; i. e., the joint exudate was clear or only slightly clouded and not much increased in quantity, the capsular thickening moderate, cartilage and bone not destroyed. Proliferation of synovial tags or granulation tissue beneath the capsule was the principal change. On the other hand, those cases from which streptococci or streptococci and bacilli together were obtained showed more marked changes in the joints than those with bacillary infection only. In all cases of the former there was enormous capsular thickening and cartilaginous destruction stood in the foreground. The cases resembling tuberculosis externally were mostly of such mixed infection. The joints in which organisms were found in sections or smears but not in cultures, were bacillary infections. The cases in which bacilli exclusively were found showed different stages, from mild to severe. In the mild cases the changes in the cartilage and bone were not marked; at most there was denudation of the surface cartilage or partial destruction of prominent points of bones; the joint exudate was clear or slightly clouded; proliferation of synovial tags and granulation tissue was the chief change. In advanced cases, however, there was tough fibrous thickening of the capsule, occasionally degeneration, calcareous, hyaline, or caseous; the joint exudate yellowish, greenish-yellow, with inspissated masses or detritus. The pus had no odor. The articular cartilages were destroyed in part and replaced by granulation tissue. Interosseous spaces were filled by granulation tissue, in which plasma cell infiltration was marked. The plasma cells appeared reduced in number where polymorphonuclear, neutrophil leukocytes were present. The destruction of cartilage and bone occurred over opposing surfaces of joint heads and sockets, the points where mechanical pressure and friction were strongest, being most affected. In some cases many giant cells were present in the marrow, not only in Howship's lacunae, but generally near or in inflammatory areas. Occasionally new formation of bone tissue was noted near the exulcerated part of the cartilage or at the insertion of the capsule. Layers of osteoblasts were seen beneath the zone of provisional calcification. Where the cartilage was not destroyed, there was no regenerative process in the underlying bone.

Granulation tissue in some sections was found beneath the surface cartilage or even beneath epiphyseal cartilage, without denudation of the cartilage at those points.

In other cases the pathologic changes in the synovial membrane (synovitis) and the perichondrium (so-called pannus) seemed to constitute the primary process, and the osseous changes appeared to be secondary.

As the cases in which streptococci were discovered showed sinuses in the skin, the streptococcal infection might be considered as secondary.

In the few cases in which the tonsils were examined there were found in the tonsils peculiar pinhead sized yellowish, caseous points, sometimes as many as 20 being seen in the tissue of the tonsils, corresponding to the outlets of lacunae. These yellowish masses were not removed readily by forceps from the tonsillar parenchyma. Microscopically, they were small abscesses, surrounded by hyalin, or firm fibrous tissue. In some sections the parenchymatous cells of tonsils were almost entirely replaced by fibrous tissue. Smears and cultures showed hemolytic streptococci and various other bacteria, but no actinomyces. The relation of these streptococci to the joint inflammation will be discussed later.

The bacilli obtained may be described briefly as follows:

DESCRIPTION OF THE BACILLI

The Bacilli.—Rods of varying size depending on conditions and growth; on agar, length 1-1.5μ, breadth 0.4-0.5; on serum, length 2-4μ, breadth 0.4-0.5; sometimes in pairs and coccal forms; no capsule; nonmotile; no flagellae; gram-positive but some older cultures retain stain poorly; no odor in cultures either aerobic or anaerobic; no visible growth on potato, but the implanted bacilli live 5 or 6 days; good growth on Loeffler's serum; no liquefaction (Culture 14 caused slight liquefaction in certain generations); in plain broth and ascites broth the supernatant fluid is sometimes clear, sometimes slightly opalescent with a small amount of whitish sediment; in dextrose broth there is slight diffuse cloudiness or the supernatant fluid is clear with sediment of yellowish brown tint; litmus milk is neither decolorized nor coagulated (Culture 14 decolorized milk); on gelatin a slight, whitish growth along needle track above its middle part, not at bottom; no liquefaction one week at room temperature. On plain agar growth is very poor in form of minute translucent round, flat colonies; condensation water almost clear, sometimes with small amount of whitish sediment; on blood agar the growth is good; nonhemolytic, only Cultures 10 and 19 showed slight hemolysis in certain generations; small round colonies after 24 hours, colorless, translucent, later whitish, but still semitranslucent.

Acid is produced in dextrose; in other sugars and higher alcohols acid production is variable. No indol is produced. The bacilli grow longer and more slender on Loeffler's serum, while on plain agar and blood agar they appear as very short bacillary or sometimes elongated coccal forms. In tissues the bacilli are usually short and frequently in coccal form, so that there is some difficulty in distinguishing them from diplococci. The bacilli show rather weak resistance to higher temperatures and lose transplantability on exposure of suspension in salt solution to 58 C. 15-30 minutes; one hour's incubation at 43 C. or half an hour at 55-56 C. does not prevent subsequent growth. The temperature optimum lies between 35-37 C.

Agglutination: In each blood agar tube of 24 hours' incubation 1 c.c. of physiologic salt solution was poured, and the colonies on the surface carefully rubbed off. This suspension was kept for 15 minutes at 58 C. and injected intravenously in rabbits at the intervals of 4-6 days. The doses injected of this suspension were increased in the order of 1-2-3 c.c. Eight days after the third injection the serum was used for agglutination tests. As rabbits are easily killed by living bacilli, heated suspensions were used. The results are illustrated in Table 1.

TABLE 1

Titer of Aglutinin in Serum of Immunized Rabbits

Serums	Cultures			
	11	16	19	20
11	320	160	320	160
19	320	320	640	160
20	40	80	40	80

Pathogenicity: The bacilli are variably pathogenic for guinea-pigs, mice and rats. Culture 11 did not kill guinea-pigs on subcutaneous injection of 0.3-5 c.c. of a blood agar culture suspended in 1 c.c. of salt solution, but killed mice in doses of 0.2-0.3 c.c., while Culture 5 killed guinea-pigs but did not kill mice in the respective doses. On the other hand, rabbits are undoubtedly susceptible. Intravenous injection of half or one blood agar slant of 24 hour cultures of Cultures 6, 11, 19, 20, all killed rabbits within 3-5-14 days. Marasmus and sepsis were the principal causes of death. Joint inflammation, chiefly synovitis, was demonstrated in two rabbits injected with Cultures 11 and 19. The result of subcutaneous injection is more variable. After death bacilli were found most frequently in the bone marrow.

In making injections the syringe, with needle attached, containing suspension of Culture 11, accidently fell point down on the thigh of a man, perforating the clothing and skin. Next day a round, reddish, slightly infiltrated spot as large as a cent appeared; 2 days later the reddening spread over the anterior surface of the thigh with well defined, slightly elevated margin and burning pain. Temperature 99.5 F. lymph-node enlargement in the groin; in the course of a week the erysipelatous reddening extended over almost the entire anterior surface of the thigh, while at the point of inoculation in the center fading commenced. There was some edema and infiltration of the underlying tissue which subsided slowly under hot dressings. After two weeks all symptoms disappeared.

INOCULATION OF BACILLI IN SWINE

Pig 1.—Feb. 19, when 24 days old, one-fourth blood agar culture of Culture 11 suspended in salt solution was injected intravenously. No symptoms; edema of ear at site of injection.

May 26.—One blood agar slant of Culture 11 subcutaneously. No symptoms.
Apr. 12.—Two slants in 1 c.c. suspension subcutaneously.
Apr. 24.—Two slants in 2 c.c. solution intravenously.
May 3.—Two slants intravenously.
May 9.—Three slants intravenously.
May 16.—No lameness. Appears well.

Pig 3.—March 26, 59 days old, one blood agar slant of Culture 20 of bacillus, intravenously. No symptoms.

Apr. 6.—One slant intravenously.
Apr. 12.—One and one-half slants intravenously.
Apr. 18.—Right hind leg stiff.
Apr. 19.—Lame; quiet.
May 3.—Two slants of Culture 20 intravenously.
May 9.—Three slants intravenously.
May 16.—No lameness; appears well.

Pig 4.—March 26, 59 days old. Growth of Culture 14 of bacillus intravenously. No symptoms.

Apr. 12.—One and one-half slants intravenously; no symptoms.
Apr. 24.—Two slants intravenously.
Apr. 3.—Three slants intravenously.
May 11.—Pig unable to use left fore leg.
May 16.—Unable to stand. Left fore leg at shoulder swollen; animal looks sick.
May 20.—Left fore leg at elbow enormously swollen. Cannot stand at all.

May 28.—Killed. Large periarticular abscesses about elbow joint of left fore leg, communicating with joint cavity and containing thick yellowish odorless pus. Capsule thick, cartilage on joint head and socket destroyed and covered by granulations; shoulder and carpal joints normal. Elbow joint of right fore leg externally slightly swollen; circumscribed abscess with thick yellowish pus, involving lateral condyle of joint head and extending into the adjacent portion of the capsule; some capsular thickening; carpal joints externally normal and movable, but on dissection a small abscess is found in capsule without connection with joint cavity; cartilage normal; synovial fluid much increased, clear, colorless. In smears many gram-positive short bacilli in pus from the abscesses of right and left elbow joints and right carpal joint. Smears of spleen, epigastric and mesenterial lymph-nodes and bile showed the same bacilli. Heartblood, peritoneal fluid and urine free from bacteria. Inoculation of blood agar slants with the pus of joints, the bile, lymph-nodes and spleen, gave minute nonhemolytic colorless colonies of the bacillus inoculated.

Pig 7.—May 3, 44 days old. Blood agar culture 24 hours old, of bacillary Culture 19, subcutaneously at right shoulder.

May 8.—Abscess at site of subcutaneous injection.

May 11.—Abscess about same. Right hind leg lame, swollen at knee.

May 14.—Swelling of right hind leg increased.

May 16.—Swelling increased; abscess in back same size as before.

May 22.—Killed. Abscess in back is about 5 cm. in diameter, filled with greenish yellowish pus with no odor; adjacent muscles pushed aside and partially destroyed. Right hind knee showed great thickening of capsule, edema in subcutaneous and muscular tissue; thick greenish-yellow pus in joint cavity; granulation tissue here and there on synovia; cartilage in places denuded; in several spots the granulation tissue extends into the bone. The tarsal joint shows some capsular thickening and a large periarticular abscess with greenish-yellow pus; the cartilage and bone of the joint destroyed in several places. Hip and phalangeal joints normal. Joints of left fore leg normal except that one phalangeal joint is swollen, due to a small abscess in the joint capsule with no apparent connection with joint cavity; cartilage and bone intact; synovial fluid clear, viscid.

Endocardium whitish, thick, not glistening; valves not deformed; no changes in lungs, spleen enlarged, hyperemic, no abscess. Liver and gallbladder normal. Kidneys normal; peritoneum rather opaque, fluid clear, not increased; slight fibrinous exudate over transverse colon and jejunum, mesenteric lymph-nodes rather large. Tonsils normal.

Many gram-positive short bacilli in smears from abscess in back, from right knee, tarsal and phalangeal joints; a few bacilli in smears from blood in heart, from spleen and mesenterial lymph-nodes. Smears from bile and renal pelvis negative. Minute, nonhemolytic dewdrop-like colonies developed in cultures from abscess in back, from left phalangeal, from right knees and tarsal joints, heart blood and spleen corresponding to culture originally inoculated.

Pig 8.—May 3, 44 days old. One blood agar slant of Culture 16, suspended in salt solution injected subcutaneously in back.

May 9.—Right fore leg lame. Induration at site of injection.

May 16.—No lameness; appears well.

June 19.—Killed. Right carpal joint showed proliferation of synovial tags and granulation tissue beneath capsule; cartilage denuded in one spot, and replaced by granulating fibrous tissue; synovial fluid clear, not much increased; capsule slightly thickened; other organs normal.

Pig 9.—Born about March 20, 1917. May 15, 56 days old. Suspension of one blood agar slant, Culture 11, subcutaneously. No symptoms.

Pig 10.—May 15, 56 days old. One blood agar slant, Culture 20, subcutaneously.

May 16.—Vomited; does not eat well.

May 17.—Well; no lameness.

Of 7 pigs, 3 were injected intravenously and 4 subcutaneously with bacilli. One of those injected intravenously showed temporary lameness in the hind leg (Pig 3), and one after repeated injections developed multiple arthritis resembling the natural disease (Pig 4). About the same results were obtained by subcutaneous injection — brief lameness in one (Pig 8) and joint infection in another (Pig 7). Both methods of injection may cause joint infection in spite of the supposition that the intravenous method would seem the surer way, as observed in other pyogenic infections. Possibly subcutaneous wounds may be one point of entry of the bacilli in this form of arthritis in swine. In Pig 7 the joint suppuration developed some time after an abscess in the back had formed.

These experiments afford examples of different stages of arthritis, i. e., from synovial proliferation to bone degeneration, which correspond well to the conditions in the natural disease. The normal condition of the lungs and pleura differs notably from the descriptions in reports on swine arthritis caused by Bacillus pyogenes; in the latter pneumonia, lung abscess and pleuritis are described as frequent.

DESCRIPTION OF STREPTOCOCCI

Small cocci in pairs and short chains; no capsule; gram-positive. On plain agar slight growth; single colonies pinpoint in size; transparent after 24 hours, becoming more opaque later with clouding of water of condensation; no odor in cultures; no visible growth on potato; on Loeffler's serum good growth with liquefaction beginning in 24 hours at 37 C.; in plain and ascites broth supernatant fluid clear with a scanty white sediment; in dextrose broth, clear above with yellowish or brownish white sediment; litmus milk decolorized and acidified, coagulation in 48 hours, clot digested slowly in one case; in gelatin very slight whitish growth along needle track. No liquefaction after 6 days at 20 C.; on blood agar all cultures gave some hemolysis (weak in Cases 1 and 2, marked in Cases 3, 10, 13 and 21). The streptococci grow aerobically as well as anaerobically. No indol produced. Raffinose and mannite not fermented; inulin fermented by Cultures 1 and 3, slightly by 2, 10, 13, and 21; glucose, maltose, saccharose fermented; lactose fermented by 1 and 3, slightly by 2, 10, 13, and 21; salicin fermented by 1, 2, and 3, slightly by 10, 13, and 21.

TABLE 2

FERMENTATIVE REACTIONS OF STREPTOCOCCI

Strains	Plain	Glucose	Inulin	Lactose	Maltose	Mannite	Neutral Red	Raffinose	Saccharose	Salicin
1	—	+	+	+	+	—	—	—	+	+
2	—	+	±	±	+	—	—	—	+	+
3	—	+	+	+	+	—	—	—	+	+
10	—	+	±	±	+	—	—	—	+	±
13	—	+	±	±	+	—	—	—	+	±
21	—	+	±	±	+	—	—	—	+	±

The streptococci obtained from the tonsillar abscesses gave very similar reactions.

With the serum of a rabbit injected with streptococcus, Culture 3, agglutination was obtained of Culture 3 at 2560, Culture 1 at 1280, Culture 2 at 80, Cultures 10 and 11 at 320, Culture 21 at 20, of streptococcus from tonsils of

Case 3 at 640, and of streptococci from other sources at 40-80. The streptococci were pathogenic for rabbits. As a rule, one 24-hour blood agar slant injected intravenously killed within 3 to 15 days from marasmus and sepsis; joint suppuration was a rather rare complication. Mice show variable susceptibility; rats relatively resistant.

INOCULATION OF STREPTOCOCCI IN SWINE

Pig 1.—April 6, when 70 days old, Pig 1 received one-half of a blood agar slant of Streptococcus 21 intravenously. No symptoms.

April 12.—One and one-half slants intravenously; no symptoms.

April 24.—Two slants intravenously.

May 3.—Two slants intravenously.

May 7.—Lame in right hind leg; no distinct swelling.

May 9.—Three slants intravenously; unable to stand.

May 10.—Better, but less active.

May 20.—Well.

Pig 5.—May 3, when 44 days old, received intravenously suspension of one blood agar slant of streptococci.

May 9.—Abscess appeared on left side of neck.

May 14.—Left hind leg lame.

May 16.—Abscess still present. Leg not distinctly lame.

May 21.—Abscess on neck, large as child's fist.

May 28.—Killed. In the left submaxillary region an abscess with fibrous edematous wall, containing thick yellowish pus with detritus. In left shoulder joint some synovial tags, fluid clear, not much increased. Left hock joint contained some proliferating synovial tags and some granulating fibrous tissue beneath the capsule; no destruction of cartilage or bone; fluid clear, viscid, slightly increased. Endocardium not glistening; some fibrous peritoneal adhesions. On cultures from abscess Streptococcus hemolyticus, Staphylococcus aureus and B. subtilis were obtained. Joint fluid negative.

Pig 6.—May 3, when 44 days old, received one slant of blood agar culture of Streptococcal intravenously.

May 8.—Right hind leg and left fore leg lame.

May 9.—Left fore leg swollen.

May 11.—Left fore leg more swollen, cannot run.

May 12.—Died. Extensive phlegmon in neck and left fore leg. In right hip joint granulation tissue beneath the capsule and in interosseal spaces; no denudation of cartilage; capsule fibrous. Hemolytic streptococci in smear and on cultures from phlegmon, heart-blood, spleen and hip joint. Cultures of phlegmonous part were contaminated by gram-positive and gram-negative large bacilli.

Altho there seems no doubt that the streptococci from swine arthritis can cause joint infection without the presence of the bacilli, it appears from a review of the pathologic changes in each case, that the streptococci as a rule are secondary to the bacillary joint infection. The streptococci may enter the body either through sinuses in the skin or through the tonsils. In fermentative reactions the streptococci obtained from joints resembled those from tonsillar abscesses in the corresponding cases.

The differences between swine streptococci and such bovine streptococci as we have been able to study seem to be that the former grow not so well anaerobically as aerobically; that the supernatant fluid in broth cultures of the former as a rule is clear; that they coagulate and acidify litmus milk, give more or less inulin fermentation, and are markedly pathogenic for rabbits.

SUMMARY

In 17 of 21 cases of chronic arthritis in swine, bacteria were found either in culture or in sections. In the 6 cases in which streptococci were found either alone or associated with bacilli, the lesions were of a chronic suppurative character, usually with external sinuses, and suggested in appearance chronic tuberculous lesions. However, careful search revealed no evidence of tuberculosis in sections, nor were there tuberculous lesions elsewhere in the animals from which these joints came.

In the 9 cases of pure bacillary infection, the joint changes varied in extent from early stages of a marginal fringe of granulation within the joint without destruction of cartilage to those of extensive exulceration of cartilage and disorganization and deformity of joints. In several of these bacillary cases, the joint fluid was clear or very slightly cloudy, with no gross evidence of suppuration. Examination of the aspirated joint fluid alone would in some instances have led to the conclusion that the joints were sterile, but bacilli were nevertheless present in sections and cultures from the granulation tissue.

The bacilli isolated from the joints in these cases are culturally alike, and in morphology and most cultural reactions resemble B. pyogenes, as described by Dutch and German veterinarians in cattle and swine, but differ from them in that they do not liquefy gelatin and Loeffler's serum. The pathologic changes produced by the bacillary infection resemble those ascribed to B. pyogenes in their chronic low grade suppurative character with tendency to the formation of granulation and fibrous tissue. The pulmonary infections described as frequent in animals infected with B. pyogenes were not observed in our cases, either in the natural disease or in experimental animals.

While the bacillary infection is apparently the etiologic agent in most of the cases included in this study, and the streptococcal infection apparently a later and secondary one, we do not wish to insist that infection by the bacilli described is the only cause of chronic arthritis in swine. There may well be other organisms of suitable virulence which can set up similar processes. It seems important, however, to emphasize the element of nontuberculous infection in chronic deforming joint lesions in animals otherwise in good health.

The economic loss entailed by chronic arthritis in swine is considerable even in those animals which reach the market in otherwise good condition, and must be still greater among animals on infected stock farms. While much further study is necessary before a complete knowledge of the etiology of the disease is possible, the present study suggests some points which may be of value in preventing the disease in young pigs. Lesions of joints were produced experimentally by subcutaneous inoculation of bacilli as well as by intravenous. It is possible that puncture wounds of the skin in infected yards may be the means of initial infection in some instances. The alimentary tract cannot be excluded, for in one case we found a marked chronic nontuberculous infection of the mesenteric lymph nodes associated with arthritis. We were prevented from carrying out the feeding experiments planned by the entry of one of us in military service. We found no clear evidence of infection by way of the respiratory tract, although a chronic sinusitis was found in one hog. In the streptococcal cases, the streptococci isolated from the tonsils resembled culturally and immunologically those isolated from the joints.

The study of arthritic lesions in market hogs does not allow of conclusions concerning the relation of the arthritis to a possible more widespread infection of the original herds with B. pyogenes, in infections with which abscesses in various organs and muscles are said to occur. It has already been noted that the bacilli found in our cases differed from B. pyogenes in their failure to liquefy serum and gelatin. The joint lesions, however, correspond with those described in joint infections by B. pyogenes.

The occurrence of arthritis in some herds and not in others also suggests local sources of infection on the affected farms. It would seem advisable to exclude from the hog-lot any animals with chronic suppurations whether swine, cattle or other animals, for the same reasons that cattle and other animals suffering from tuberculosis are excluded to prevent tuberculosis among the hogs.

EXPLANATION OF PLATES 10 AND 11

Fig. 1 (Case 14).—Proliferation of synovial tags. × 90.

Fig. 2 (Case 4).—Granulation tissue in place of synovial tags. 1. Plasma cell infiltration. 2. Dilated vessels. 3. Obliterated vessel. × 70.

Fig. 3 (Case 9).—Destruction of surface cartilage. 1. Fibrous· tissue in place of cartilage. 2. Island of cartilaginous tissue. 3. Bone tissue. × 90.

Fig. 4 (Case 6).—Subchondral granulation tissue. 1. Proliferation of cartilaginous cells. 2. Zone of calcification. 3. Granulating fibrous tissue in marrow spaces. 4. Layer of osteoblasts. × 60.

Fig. 5 (Case 21).—Giant cells in bone marrow. 1. Giant cells. 2. Granulating fibrous tissue in marrow spaces. 3. Bone trabeculae. × 90.

Fig. 6 (Case 3).—Small abscesses in tonsils. 1. Abscesses. 2. Hyaline fibrous tissue. × 60.

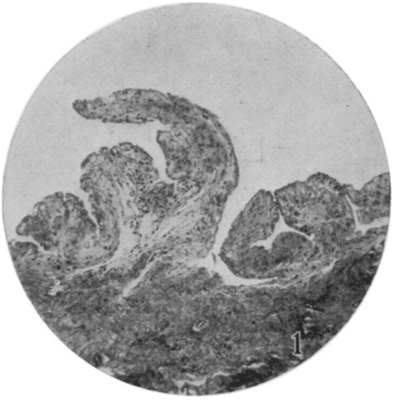
Fig. 7 (Case 6).—The bacilli in tissue, Gram stain. × groups of bacilli. × 1200.

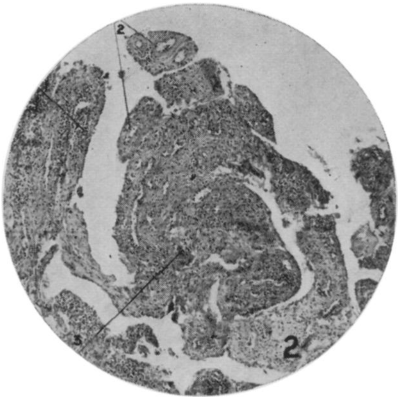
Fig. 8 (Case 16).—The bacilli on blood agar culture, 24 hours. × 1200.

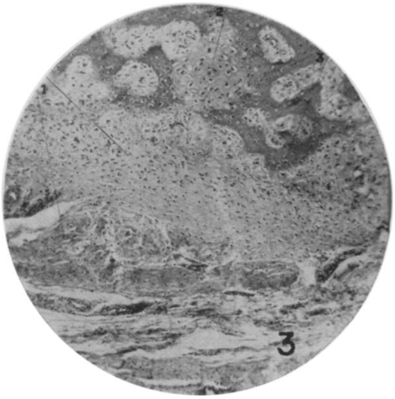
Fig. 9 (Case 16).—The bacilli on Loeffler's serum; 24 hours. × 1200.

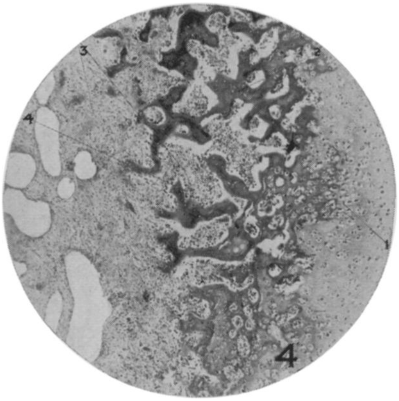
Fig. 10.—Arthritis produced by inoculation of the bacilli from Case 19.

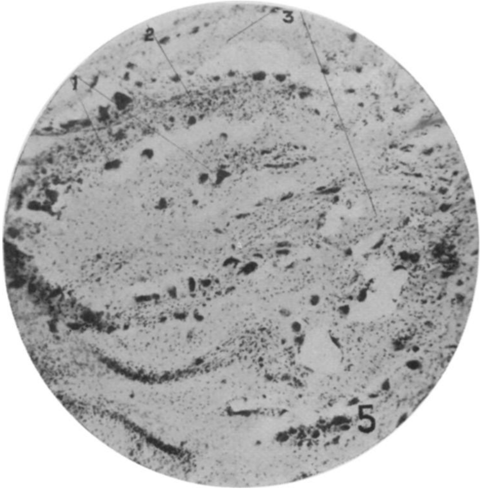
PLATE 10











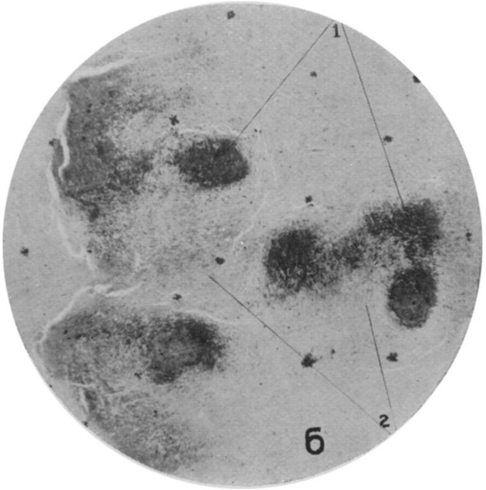


PLATE 11